Proactive environmental control of storage areas for cultural heritage

First lessons learnt from implementing AI and ML in practice

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Welcome

Hi, my name is Ulla Bøgvad Kejser –senior researcher and conservator at the Royal Danish Library

Teaser for online workshop at Fantastic Futures 21 December 6th

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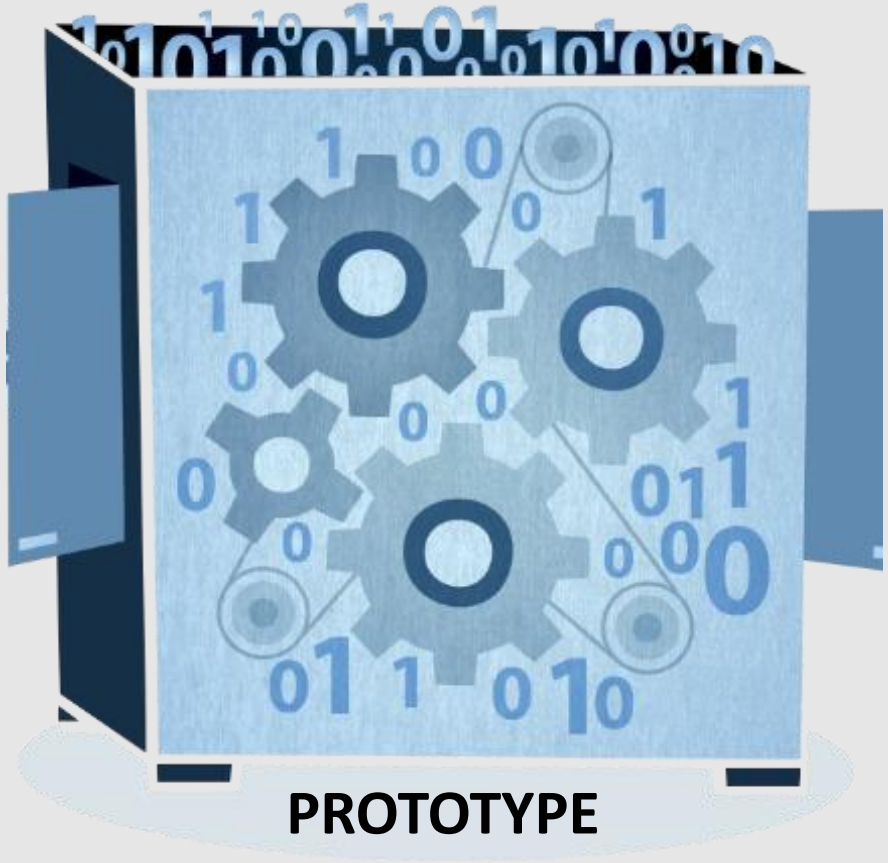
Online workshop at Fantastic Futures 2021



- Demo of prototype
  - Early warning of unwanted indoor humidity levels in storage and exhibitions areas intended for cultural heritage
- Discuss, exchange knowledge, challenge, improve

Intended audience and benefits of workshop

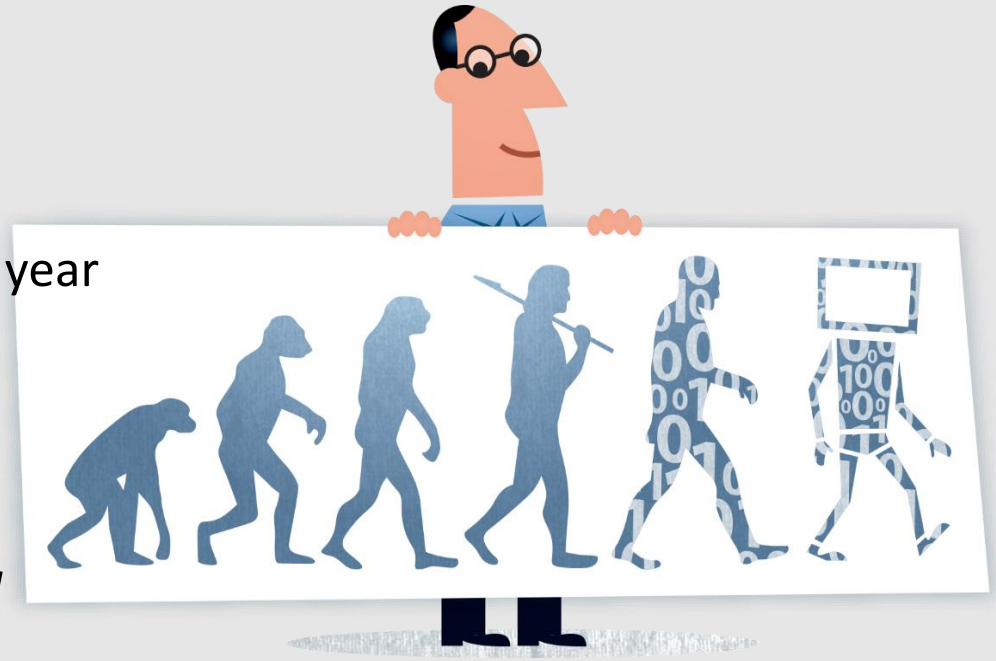
- Curators, conservators and conservation scientists, working with preventive conservation
  - Lessons learnt useful for setting up own machine learning projects
- Facility managers at galleries, libraries, archives, museums (GLAM)
  - Integration of machine learning technology in daily facility operation
- Data scientists working with GLAM institutions
  - Opportunity to challenge prototype concepts and improve performance

Cross-domain research group

- Conservator team
  - Morten Ryhl-Svendsen
    - Royal Danish Academy, Institute for Conservation
  - Birgit Vinther Hansen
    - Royal Danish Library, Preservation
  - Ulla Bøgvad Kejser
    - Royal Danish Library, Preservation
- DBC Digital team
  - Christian Boesgaard
  - Søren Højlund Mollerup
  - Noah Torp-Smidt

Project maturing and development – funded by the Danish Ministry of Culture

- Pilot study 2019
  - Prediction of the brittleness of historic paper
    - Dataset with 756 paper samples
    - No. handfoldings (brittleness), pH, color, creation year
    - Random Forest Classification (accuracy 79%)
    - Link to ICOM-CC 21 abstract
- Research project 2020-2022
  - *"Learning machines to predict environmental risks to cultural heritage preservation"*
  - Develop a prototype to predict harmful environmental conditions



Overview of the rest of the recording

- Risks to cultural heritage caused by humidity
- Case study
- Data preparation and analysis
- Prototype development

Hi, my name is Birgit Vinther Hansen
- conservator at the Royal Danish Library

Risk to cultural heritage in storage

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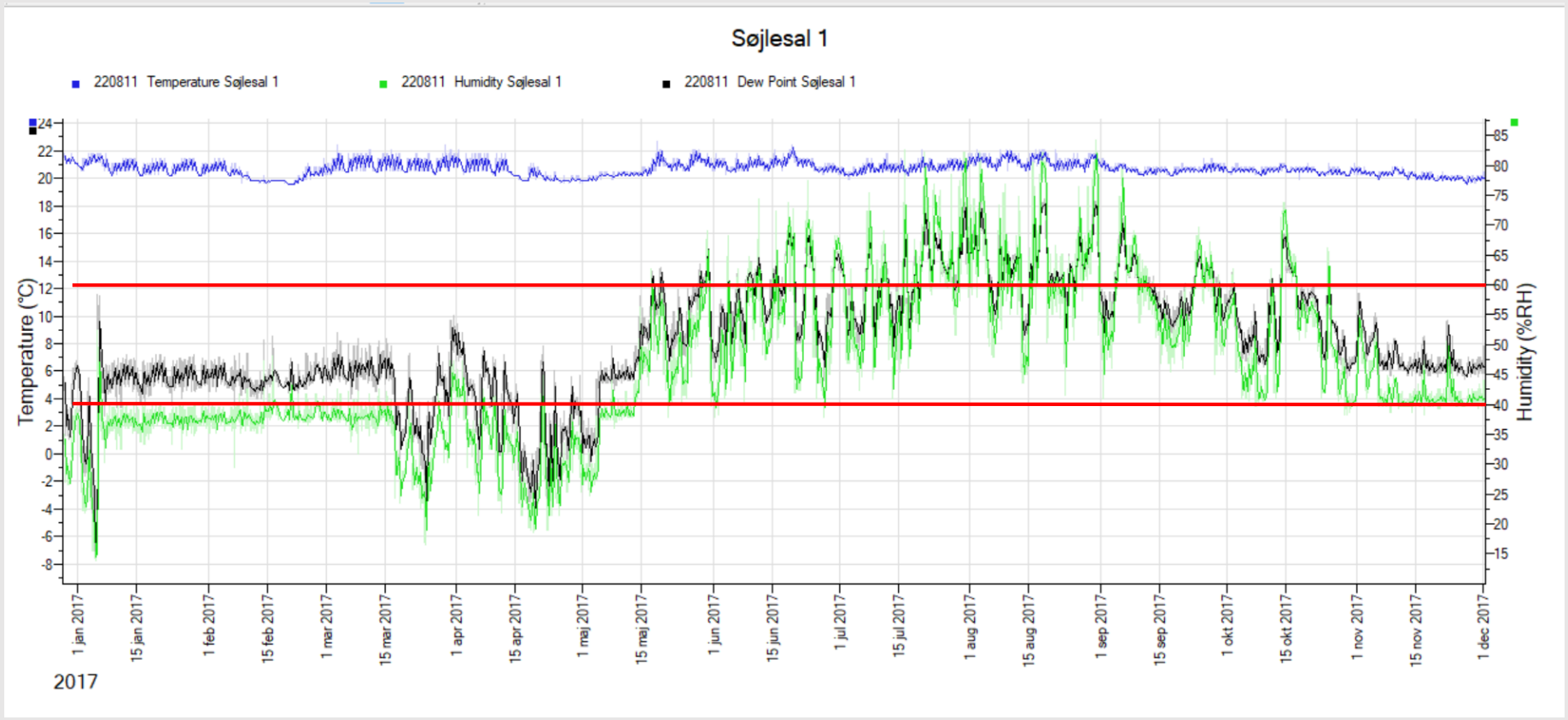
Climate risks to cultural heritage

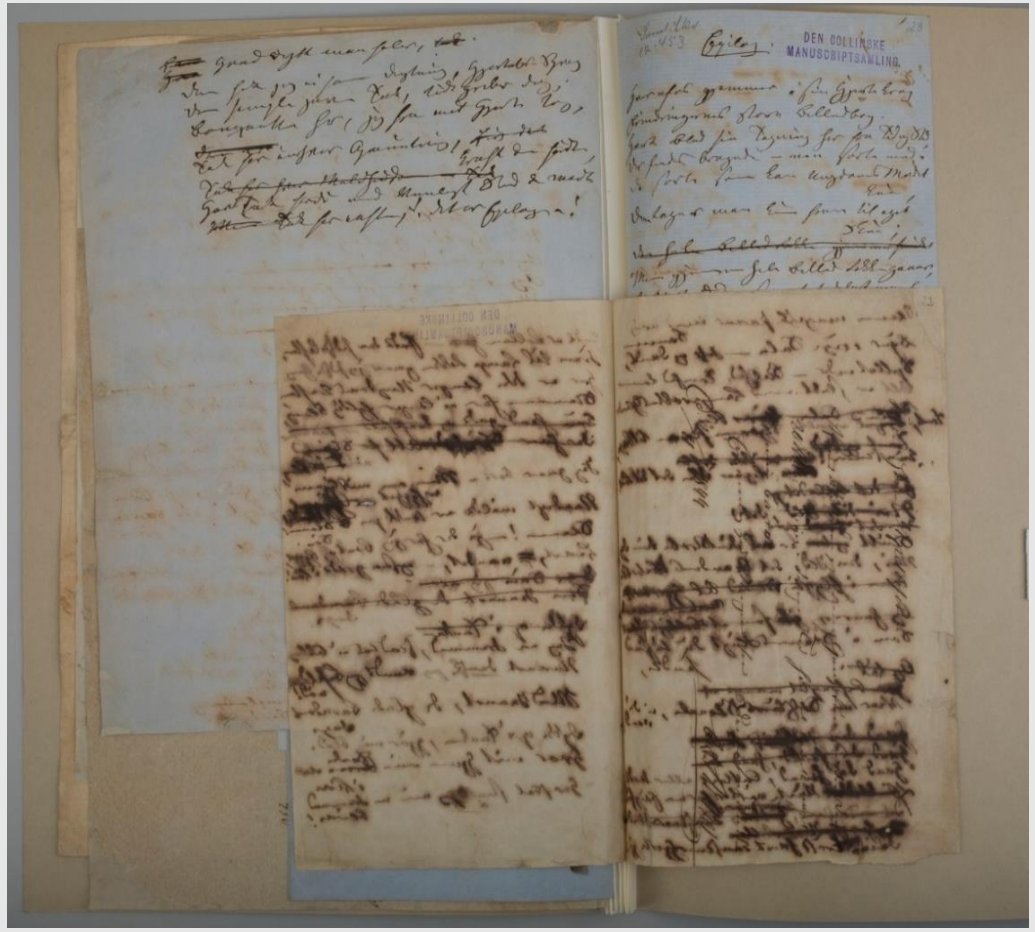
Bizot Green Protocol Guidelines (Environmental sustainability - reducing museums' carbon footprint)

40-60 % with fluctuations of no more than ±10% RH per 24 hours within this range.

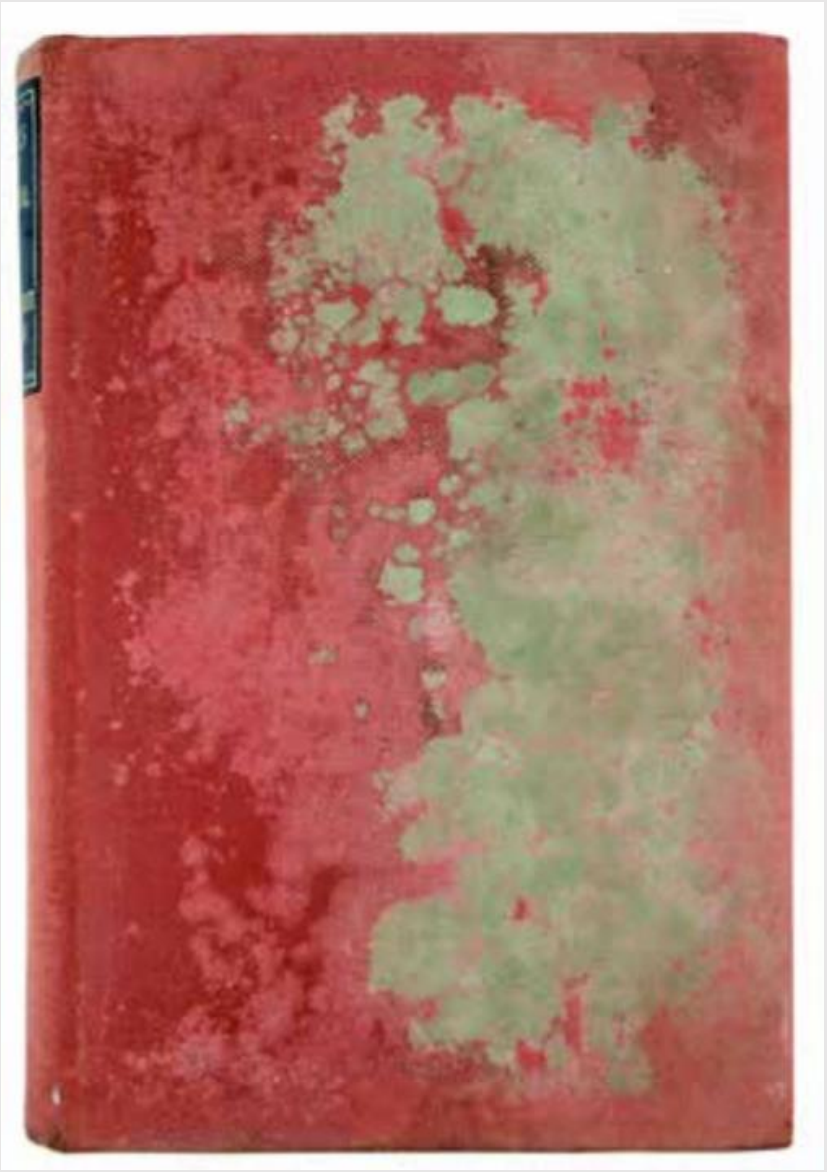


Cockling of paper due to high humidity

Bleeing of ink due to <u>high</u> humidity



Growth of mold due to high humidity

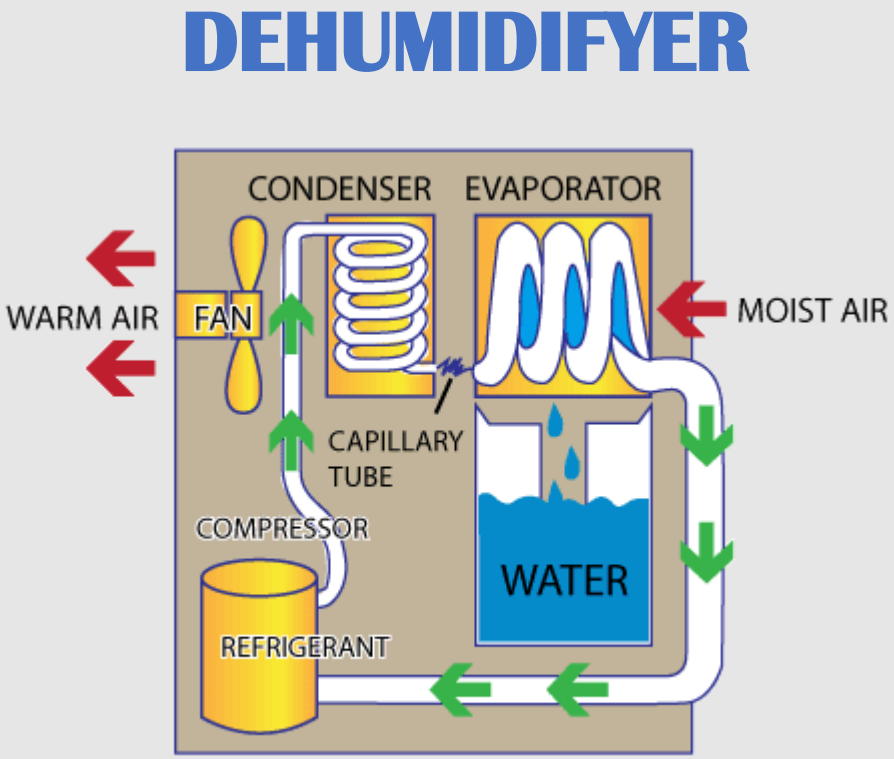


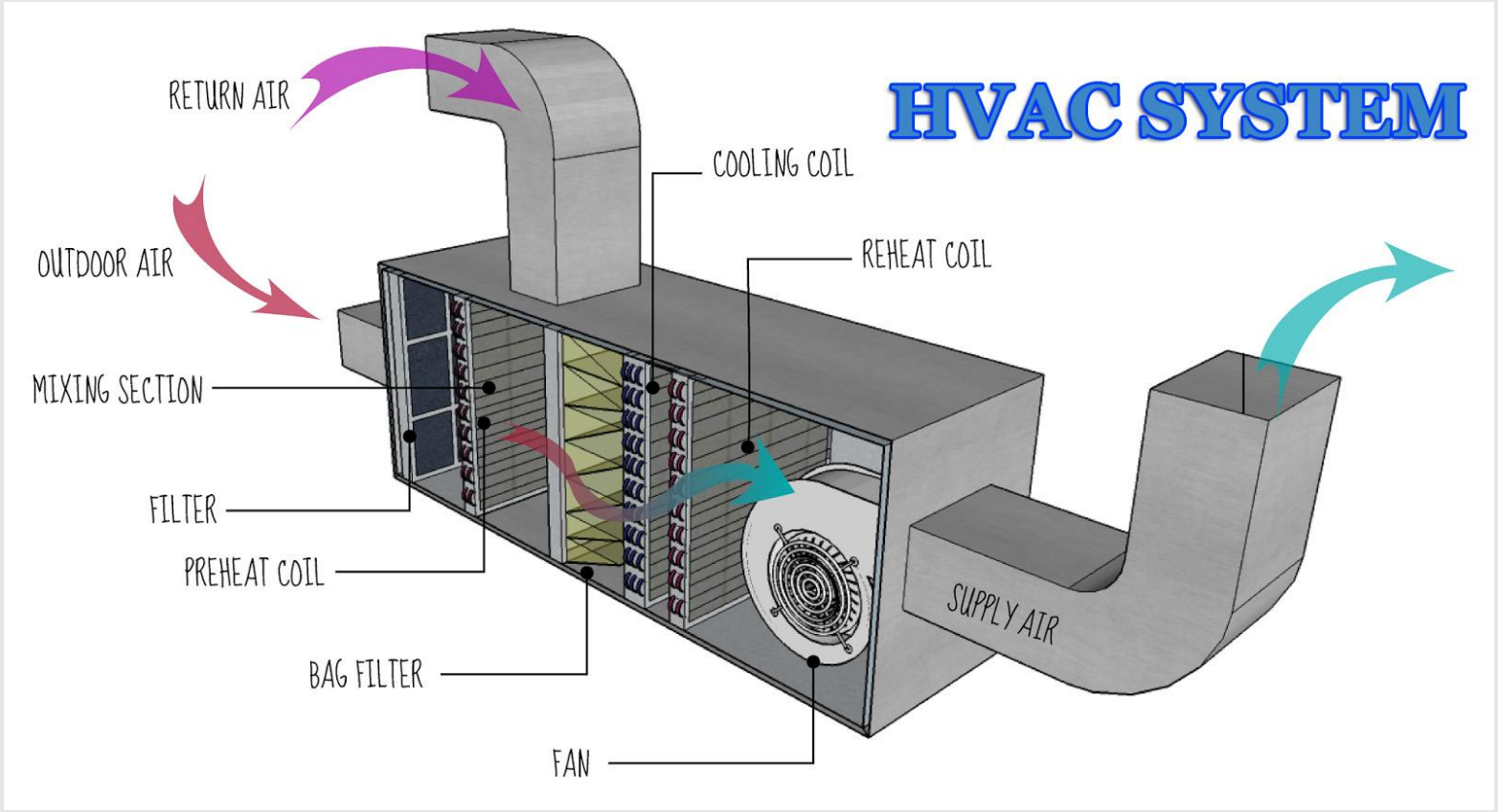
Deformation of parchment and photographs due to low humidity

Loss of paint in a polychrome wooden sculpture caused by large fluctuations in relative humidity (Image courtesy of ICCROM Archives).

Cannon balls made of iron suffering from corrosion because of high relative humidity (Image courtesy of José Luiz Pedersoli Jr.).

Climate control





Case study

- Our test site is the National Museum storage facility (Ørholm, Denmark)

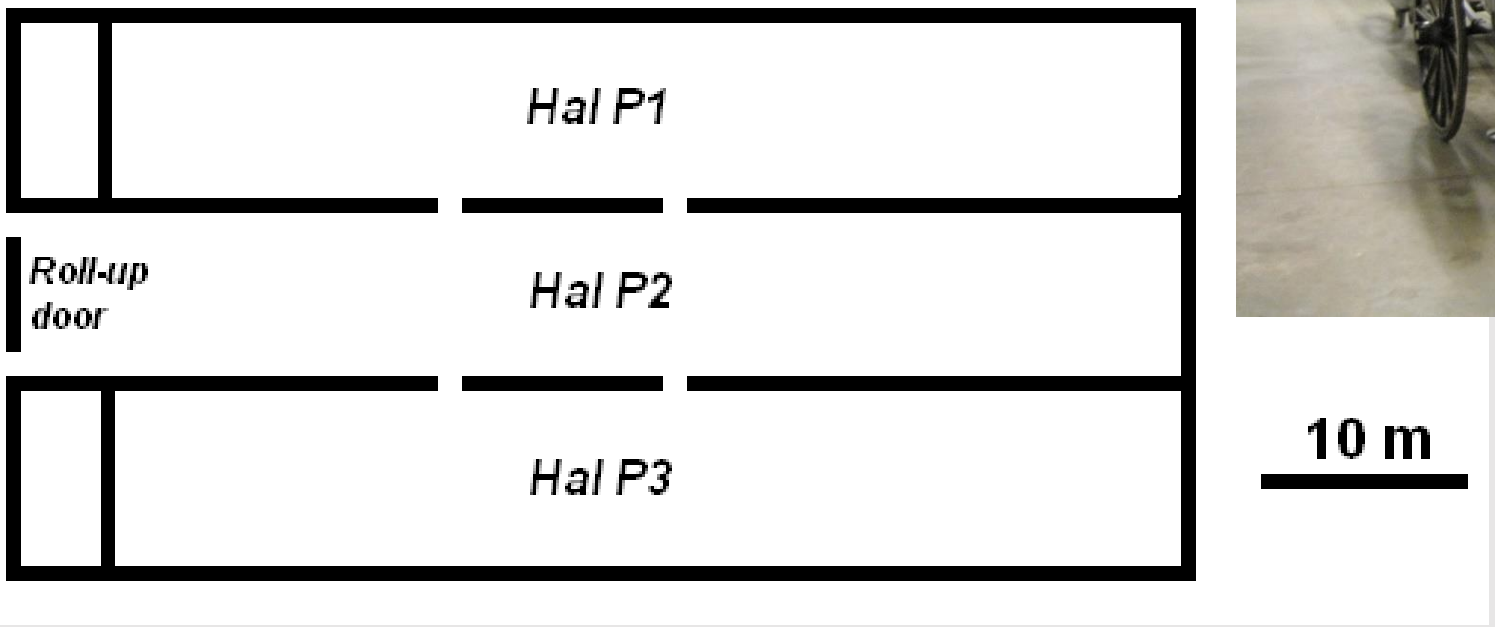
Presentation of Storage Hall P

- Humidity controlled
- Semi-airtight building
- Large objects collection
- Long climate data set (2008-> now)

Click on image for movie

Inside the store

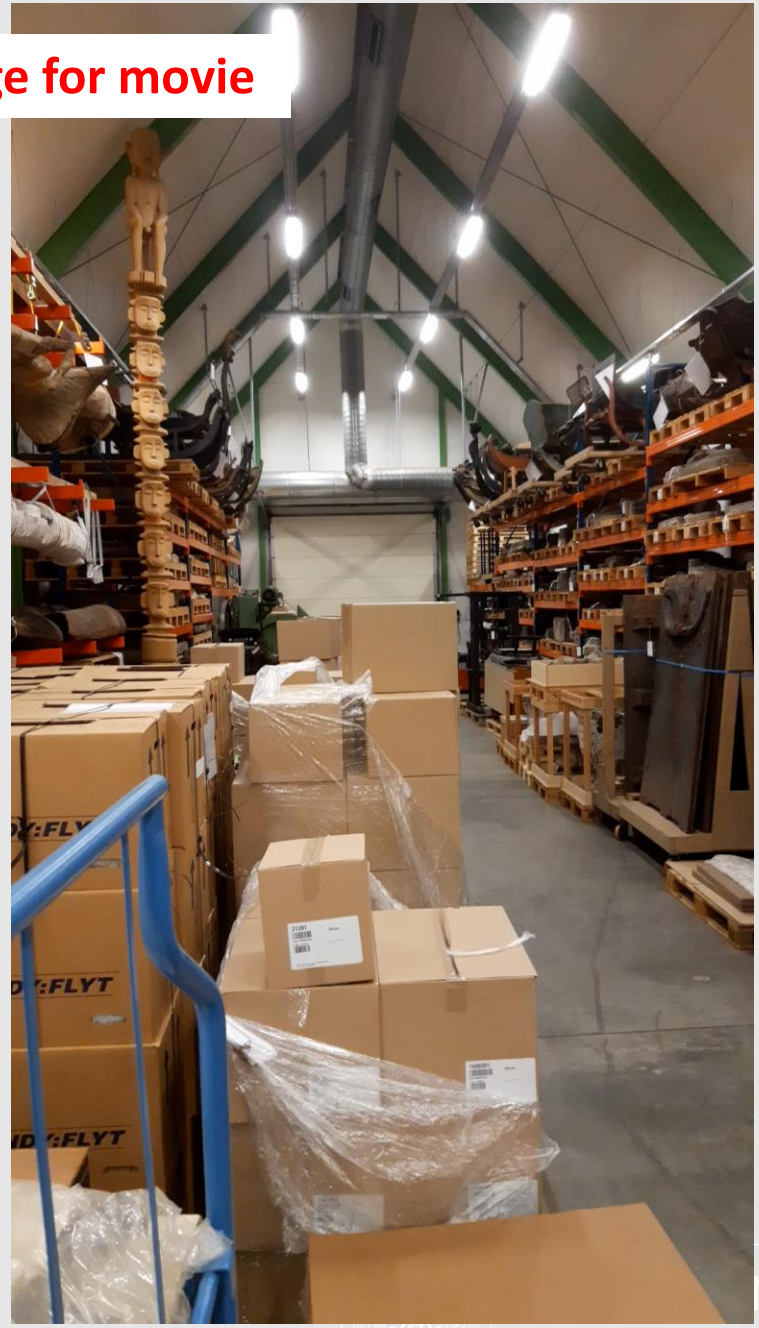
- Objects are stored in three adjoined halls, in a controlled climate



The collection climate

- Relative humidity should be between 40-60% (by mechanical dehumidification)
- The building is not heated
- Climate is monitored by sensors connected to the building management system

Click on image for movie



Climate control

- The climate sensors controls the air conditioning system, which dehumidifies air if necessary

- Climate data is recorded and stored hourly

Click on image for movie ->

Other data

- We also monitor air pollution inside and outside the building.

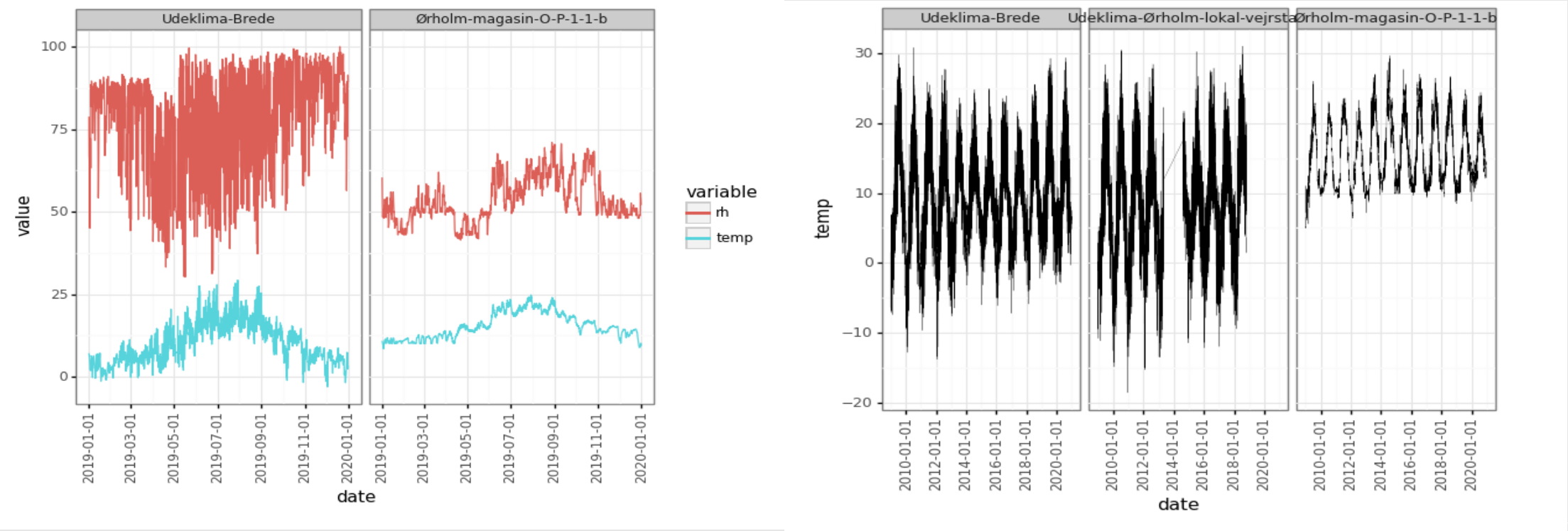
- Outdoor weather data is provided online from a nearby national meterological weather station.

Data Preparation and Analysis

- We have access to several years of hourly measurements from the three storage buildings.
- Also pulled in meterological data from DMI.
- **Task**: Is there some way to predict extreme humidity levels before they occur?
- Begin by visualizing data in order to make high-level "eye tests".

Sample Graphs – Inside and Out

- Unable to detect pattern just by looking => time for ML.

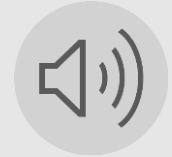


Model Building

- Prediction is a Time Series Analysis problem.
- Load data into standard ML data structures, and calculate auxiliary feature values to help estimators.
- Gather data in "rolling windows", and shift humidity values to get feature values together with humidity values "in the future".
- Define humidity thresholds as labels, and treat as two binary classification problems.
- Jupyter Notebook here.

Main Points from Code

- Created "simple" model with RandomForestClassifier from sklearn
  - Yielded OK results, but felt we could do better
- More advanced model using Gradient Boosting (XGBoost).
  - Even better results on the same training/test data split as above.



Numbers for `y_high`:

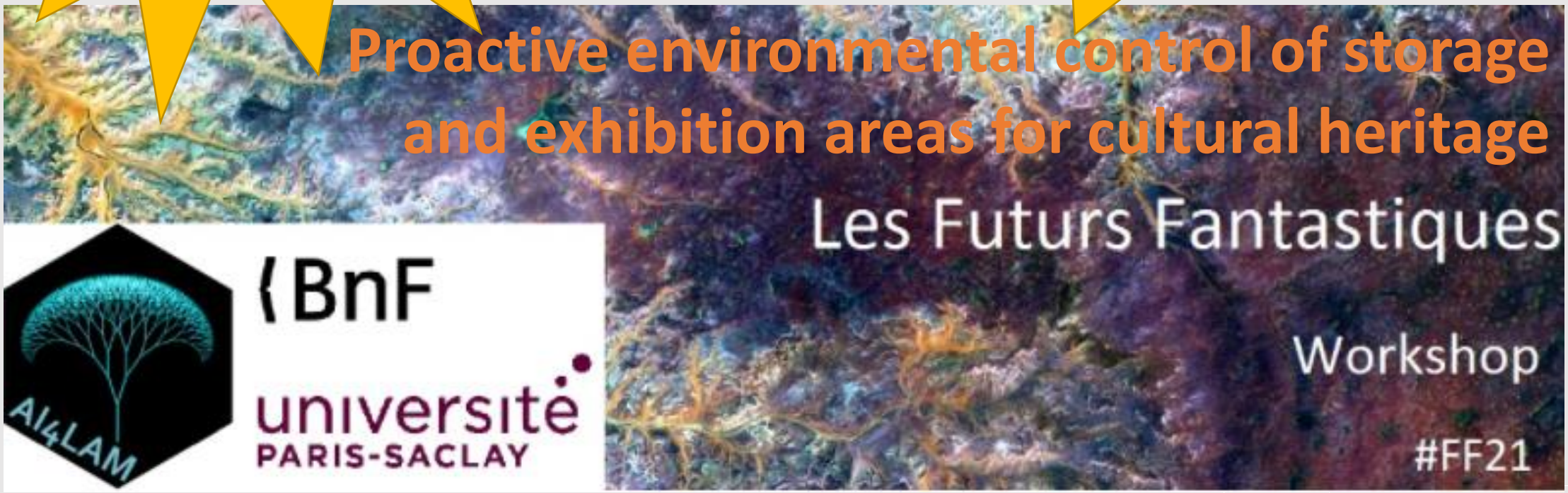
```
best params: {'learning_rate': 0.05, 'max_depth': 100, 'n_estimators': 500}
              precision    recall  f1-score

           0       0.99      0.99      0.99
           1       0.92      0.92      0.92
```

Prototype – Risk Prediction

- Set up daily job that fetches data, runs prediction, and sends email in case we predict high or low humidity.
- Predict script in this notebook.
- In a three week period in October and November, it has sent out 2 warnings, predicting high humidity.
  - Both hit the mark: humidity was high the following day
  - No non-predicted incidents at the time of writing

Link to registration:
https://bnf-fr.zoom.us/meeting/register/tJMkcuyqqT8jH9Jnk1hfGVjEEMFGU20afJ38

Sign up for our workshop on December 6th from 9-10 UTC / 10-11 CET



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